Detector for Advanced Neutron Capture Experiments (DANCE)

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Relevance to Combating Terrorism:

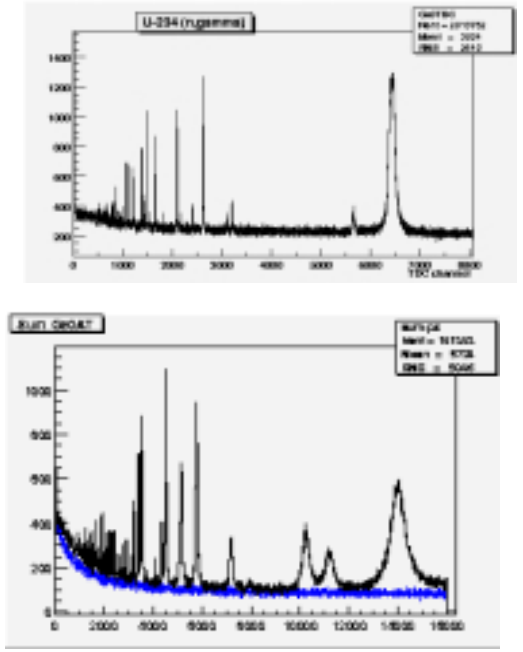
The DANCE offers an exceptional capability to do elemental and isotopic identification of materials that might be recovered following an act of terrorism. Samples on the order of a milligram could be rapidly assayed to determine isotopic composition by identifying characteristic neutron capture parameters associated with specific isotopes. This isotopic fingerprint of a sample could provide information to establish attribution of the source a the material, as well as identifying potentially dangerous compositions. The analysis could be done with minimal pre-processing, and since only small quantities are required, they could be obtained from terrorist debris or clandestine operations.

Scientific Background

The DANCE was designed to study neutron capture reactions on small quantities (1 mg or less) of radioactive nuclei using the intense, moderated, pulsed neutron source at LANSCE. The detector consists of 160 barium fluoride crystals completely covering the surface of a sphere in a “soccer-ball” arrangement. The detector will measure all gamma rays emitted following neutron capture with an energy threshold of about 0.5 MeV and an energy resolution of 12%. Preliminary measurements on the flight path have been made using existing detectors, and the DANCE is expected to be completed by December, 2002. Testing and some measurements can be done with a partial array.

Preliminary Data

Neutron capture resonances can provide a unique signature of the isotopes present in a sample, and can have cross sections up to tens of kilobarns for some elements. Measurement of small quantities of sample material requires both a high neutron flux in the resonance region (approx. 1 eV to 1 keV) and an efficient gamma-ray detector. Shown in the adjacent column are preliminary neutron capture data obtained on a 0.5 mg sample of ^{151}Sm and an 8 mg sample of ^{234}U at the DANCE flight path (FP14) at the Manuel J. Lujan Jr. Neutron Scattering Center at LANSCE. These measurements used two C_6D_6 scintillators to detect the gamma rays following capture; this arrangement is about 10% efficient. The DANCE array will be nearly 100% efficient. The large resonance near channel 14,000 (1.088 eV) in the ^{151}Sm spectrum has a 10,000 barn cross section.



Neutron time-of-flight spectra from neutron capture on ^{151}Sm and ^{234}U. The scale is 100 ns/channel. The ^{151}Sm spectrum was acquired in 15 hours, the ^{234}U spectrum in 6 hours.

Program of Research

While there are many tools available to measure isotopic compositions, resonance neutron capture may offer advantages by utilizing the very large neutron capture cross sections for many isotopes and the high neutron flux available at a spallation neutron source. The research program will consist of developing the technique as an analytic tool, evaluating it's strengths, weaknesses, and appropriate mass range, and comparing it to other analytical techniques.

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